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(54) Duplexer and communication apparatus

(57) The invention provides a duplexer (31), comprising: a first frequency variable type filter (45) including a voltage-controllable reactance element (D1, D2, D3, D4) and operative to switch transmitting - receiving frequencies corresponding to a first communication system (GSM); a second frequency variable type filter (46) including a voltage-controllable reactance element (D5, D6, D7, D8) and operative to switch transmitting - receiving frequencies corresponding to a second communication system (DCS); a synthetic circuit (47) elec-

trically connected between one end of said first frequency variable type filter (45) and one end of said second frequency variable type filter (46); an antenna terminal (ANT) electrically connected to said synthetic circuit (47); a first external terminal (P1) electrically connected to the other end of said first frequency variable type filter (45); and a second external terminal (P2) electrically connected to the other end of said second frequency variable type filter (46).

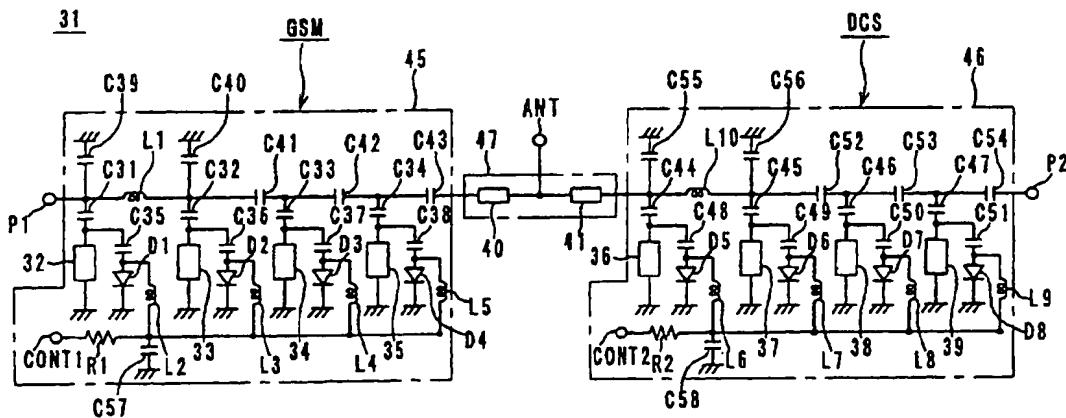


FIG. 1

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Description**BACKGROUND OF THE INVENTION****1. Field of the Invention**

[0001] The present invention relates to a duplexer and communication apparatus for use in a microwave band, for example.

2. Description of the Related Art

[0002] In recent years, a portable telephone terminal device having the function which can correspond to two portable telephone systems has been practically used. Typically, known is a dual band (Dual - Band) system composed of GSM(Global System for Mobile) and DCS (Digital Communication System). Conventionally, the portable telephone terminal device having the above function comprises two duplexers which can correspond to the respective systems independently, and are simply electrically connected to each other.

[0003] That is, as shown in FIG. 7, a conventional portable telephone terminal device 1 is provided with a duplexer 28 corresponding to the GSM system and a duplexer 29 corresponding to the DCS system. These duplexers 28 and 29 are electrically connected to an antenna terminal ANT through a synthetic circuit 30. The duplexer 28 has a band-elimination filter 21 on the transmission terminal Tx1 side thereof and a band-pass filter 22 on the reception terminal Rx1 side thereof. The duplexer 29 has a band-elimination filter 23 on the transmission terminal Tx2 side thereof and a band-pass filter 24 on the reception terminal Rx2 side thereof. In FIG. 7, resonators are designated by the reference numerals 2 through 13, transmission lines by the numerals 15 and 16, capacitors by the codes C1 through C24, and coils by the codes L1 through L6.

[0004] In addition, known is a frequency variable type filter (see Japanese Unexamined Patent Publication No. 7-321509) in which reactance elements such as a variable capacity diode, a PIN diode, and so forth is connected to a resonator through a capacitor and so forth, and these elements are voltage-controlled to vary the resonance frequency. It has been proposed that the GSM system and the DCS system are taken as one wide band system, and a portable telephone terminal device is formed by use of the above frequency variable type filter.

[0005] However, if the two duplexers 28 and 29 are electrically connected to each other, simply, there is caused the problem that the portable telephone terminal device becomes large in size. The GSM system is operated in the 900 MHz band, while the DCS system is done in the 1800 MHz band. Accordingly, if the frequency variable type filter is used, the change amount of the frequency is large (about 900 MHz), and the impedance of the resonance circuit of the frequency

variable type filter is significantly changed, due to an added reactance element. Thus, there is the problem that the coupling coefficients of the filters can be matched with difficulty, between the GSM and DCS systems, and required filter characteristics can not be attained.

SUMMARY OF THE INVENTION

[0006] To overcome the above described problems, the present invention provides a small-size duplexer and communication apparatus which can correspond to a dual band system of which the frequency bands are significantly different.

[0007] The present invention provides a duplexer, comprising: a first frequency variable type filter including a voltage-controllable reactance element and operative to switch transmitting - receiving frequencies corresponding to a first communication system; a second frequency variable type filter including a voltage-controllable reactance element and operative to switch transmitting - receiving frequencies corresponding to a second communication system; a synthetic circuit electrically connected between one end of said first frequency variable type filter and one end of said second frequency variable type filter; an antenna terminal electrically connected to said synthetic circuit; a first external terminal electrically connected to the other end of said first frequency variable type filter; and a second external terminal electrically connected to the other end of said second frequency variable type filter.

[0008] One portable telephone system can be formed of one frequency variable type filter since the transmitting - receiving frequencies of the frequency variable type filter are switched. Therefore, with the two frequency variable type filters, one duplexer can be formed which correspond to two portable telephone systems having significantly different frequency bands. Accordingly, as compared with the case that two duplexers are electrically connected simply, the duplexer can be miniaturized.

[0009] Further, when a transmitting signal is passed through the first and second frequency variable type filters, the PIN diodes are turned on. Thus, even if a high power high frequency signal is input through the first or second external terminal, the PIN diodes are prevented from being off, so that the distortion of the frequency characteristics of the PIN diodes can be inhibited. Further, when a receiving signal is passed through the first and second frequency variable type filters, no power can be consumed while a receiving signal is waited for, by setting the PIN diodes to be in the OFF state.

[0010] Further, the communication apparatus of the present invention includes any one of the antenna devices having the above characteristics, and thereby, can be miniaturized.

[0011] Other features and advantages of the present invention will become apparent from the following

description of the invention which refers to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

FIG. 1 is an electric circuit diagram showing a first embodiment of the antenna device according to the present invention.

FIG. 2 is a cross-sectional view showing a resonator used in the duplexer of FIG. 1.

FIG. 3 is an explanatory illustration of the filter characteristics of the duplexer of FIG. 1.

FIG. 4 is an electric circuit showing a second embodiment of the duplexer of the present invention.

FIG. 5 is a block diagram showing an embodiment of the communication apparatus of the present invention.

FIG. 6 is an electric circuit diagram showing another embodiment.

FIG. 7 is an electric circuit diagram showing the essential part of the PF portion of a conventional portable telephone terminal device.

DESCRIPTION OF THE EMBODIMENTS

[First Embodiment, FIGS. 1 through 3]

[0013] FIG. 1 shows the circuit arrangement of a duplexer 31. The duplexer 31 comprises a frequency variable type filter 45 corresponding to the GSM system, and a frequency variable type filter 46 corresponding to the DCS system, and a synthetic circuit 47 electrically connected between the filters 45 and 46. The filter 45 is electrically connected between an external terminal P1 and an antenna terminal ANT. The filter 46 is electrically connected between an external terminal P2 and the antenna terminal ANT.

[0014] In the frequency variable type filter 45, the two-stage resonance circuits lying on the external terminal P1 side form a band-elimination filter section, while the two-stage resonance circuit on the antenna terminal ANT side form a band-pass filter. That is, the band-elimination filter section of the filter 45 is formed by electrically connecting the series resonance circuit of a resonator 32 and a resonance capacitor C31 to the series resonance circuit of a resonator 33 and a resonance capacitor C32 through a coupling coil L1. The resonance capacitors C31 and C32 determine the extent of the elimination-band attenuation of the GSM system. Further, capacitors C39 and C40 are electrically connected in parallel to these two series resonance circuits.

[0015] A PIN diode D1 as a reactance element, with the cathode grounded, is electrically connected through a band-varying capacitor C35 to the intermediate node

between the resonator 32 and the resonance capacitor C31, in parallel to the resonator 32. A PIN diode D2, with the cathode grounded, is electrically connected through a band-varying capacitor C36 to the intermediate node between the resonator 33 and the resonance capacitor C32, in parallel to the resonator 33. The band-varying capacitors C35 and C36 function to change the two attenuation pole frequencies as the attenuation characteristics of the band-elimination filter section, respectively.

[0016] In the band-pass filter section of the filter 45, the series resonance circuit of a resonator 34 and a resonance capacitor C33 is electrically connected to the series resonance circuit of a resonator 35 and a resonance capacitor C34 through a coupling capacitor 42. The band-pass filter section is electrically connected to the band-elimination filter section of the filter 45 through a coupling capacitor C41.

[0017] The series circuit of a band-varying capacitor C37 and a PIN diode D3, with the cathode of the PIN diode D3 grounded, is electrically connected to the intermediate node between the resonator 34 and the resonance capacitor C33, in parallel to the resonator 34. The series circuit of a band-varying capacitor C38 and a PIN diode D4, with the cathode of the PIN diode D4 grounded, is electrically connected to the intermediate node between the resonator 35 and the resonance capacitor C34, in parallel to the resonator 35.

[0018] A voltage controlling terminal CONT1 is electrically connected to the intermediate node between the anode of the PIN diode D1 and the band-varying capacitor C35 through a controlling voltage feeding resistance R1, a capacitor C57, and a choke coil L2, and also, is electrically connected to the intermediate node between the anode of the PIN diode D2 and a band-varying capacitor C36 through the resistor R1, the capacitor C57, and a choke coil L3, and further, is electrically connected to the intermediate node between the anode of the PIN diode D3 and a band-varying capacitor C37 through the resistor R1, the capacitor C57, and the choke coil L4, and still further, is electrically connected to the intermediate node between the anode of the PIN diode D4 and the band-varying capacitor C38 through the resistor R1, the capacitor C57, and a choke coil L5.

[0019] In the frequency variable type filter 46, the two-stage resonance circuits lying on the ANT terminal side form a band-elimination filter section, while the two stage resonance circuits on the external terminal P2 side form a band-pass filter section. That is, the band-elimination filter section of the filter 46 is formed by electrical connection of the series resonance circuit of a resonator 36 and a resonance capacitor C44 to the series resonance circuit of a resonator 37 and a resonance capacitor C45 through a coupling coil L10. The resonance capacitors C44 and C45 determine the extent of the elimination-band attenuation of the DCS system. Further, capacitors C55 and C56 are electrically connected in parallel to these two series resonance circuits,

respectively.

[0020] A PIN diode D5, with the cathode grounded, is electrically connected to the intermediate node between the resonator 36 and the resonance capacitor C44 through a band-varying capacitor C48, in parallel to the resonator 36. A PIN diode D6, with the cathode grounded, is electrically connected to the intermediate node between the resonator 37 and the resonance capacitor C45 through a band-varying capacitor C49, in parallel to the resonator 37. The band-varying capacitors C48 and C49 are provided to vary the two attenuation pole frequencies as the attenuation characteristics of the band-elimination filter section.

[0021] In the band-pass filter section of the filter 46, the series resonance circuit of a resonator 38 and a resonance capacitor C46 is electrically connected to the series resonance circuit of a resonator 39 and a resonance capacitor C47 through a coupling capacitor C53. The band-pass filter section is electrically connected to the band-elimination filter section of the filter 46 through a coupling capacitor C52.

[0022] The series circuit of a band-varying capacitor C50 and the PIN diode D7, with the cathode of the PIN diode D7 grounded, is electrically connected to the intermediate node between the resonator 38 and the resonance capacitor C46, in parallel to the resonator 38. The series circuit of a band-varying capacitor C51 and the PIN diode D8, with the cathode of the PIN diode D8 grounded, is electrically connected to the intermediate node between the resonator 39 and the resonance capacitor C47, in parallel to the resonator 39.

[0023] A voltage controlling terminal CONT2 is electrically connected to the intermediate node between the anode of the PIN diode D5 and the band-varying capacitor C48 through a controlling voltage feeding resistance R2, a capacitor C58, and a choke coil L6, is electrically connected to the intermediate node between the anode of the PIN diode D6 and the band-varying capacitor C49 through the resistor R2, the capacitor C58, and a choke coil L7, is electrically connected to the intermediate node between the anode of the PIN diode D7 and the band-varying capacitor C50 through the resistor R2, the capacitor C58, and a choke coil L8, and further, is electrically connected to the intermediate node between the anode of the PIN diode D8 and the band-varying capacitor C51 through the resistor R2, the capacitor C58, and a choke coil L9.

[0024] The synthetic circuit 47 is a phase circuit comprising a transmission line 40 electrically connected between the frequency-variation filter 45 and the antenna terminal ANT, and a transmission line 41 electrically connected between the frequency-variable type filter 46 and the antenna terminal ANT.

[0025] Further, as the resonators 32 through 39, dielectric resonators are used as shown in FIG. 2, for example. FIG. 2 shows a resonator 32 as a typical example. Each of the dielectric resonators 32 through 39 is formed of a cylindrical dielectric 51 made of a

material with a high dielectric constant such as ceramics of a TiO_2 type or the like, an outside conductor 52 formed on the outer peripheral surface of the cylindrical dielectric 51, and an inside conductor 53 formed on the inner peripheral surface of the cylindrical dielectric 51. The outside conductor 52, at the opening end-face 51a (hereinafter, referred to as an opening side end-face 51a) lying on one side of the dielectric 51, is electrically released (separated) from the inside conductor 53. At the opening end-face 51b lying on the other side (hereinafter, referred to as a short-circuiting side end-face 51b), the outside conductor 52 is electrically short-circuited (conducted) to the inside conductor 53. At the opening side end-face 51a, the dielectric resonator 32 is electrically connected to the series circuit of the band-varying capacitor C35 and the PIN diode D1, with one end of the band-varying capacitor C35 connected to the inside conductor 53 and the cathode of the PIN diode D1 grounded. At the short-circuiting side end-face 51b, the outside conductor 52 is grounded.

[0026] Hereinafter, the act and effect of the duplexer 31 having the above arrangement will be described. When the duplexer 31 corresponds to the GSM system, a GSM transmitting signal fed to the external terminal P1 of the transmitting circuit system of the GSM system is output from the antenna terminal ANT through the transmission line 40 of the frequency-variable type filter 45 and the synthetic circuit 47. A GSM receiving signal received through the antenna terminal ANT is output from the external terminal P1 to the reception circuit system of the GSM system through the transmission line 40 of the frequency variable type filter 45 and the synthetic circuit 47. On the other hand, when the duplexer 31 corresponds to the DCS system, a DCS transmitting signal fed to the external terminal P2 through the transmission circuit system of the DCS system is output from the antenna terminal ANT through the transmission line 41 of the frequency-variable type filter 46 and the synthetic circuit 47. A DCS receiving signal received through the antenna terminal ANT is output from the external terminal P2 to the reception circuit system of the DCS system through the transmission line 41 of the frequency-variable type filter 46 and the synthetic circuit 47.

[0027] The trap frequency of the band-elimination filter section of the frequency-variable type filter 45 which corresponds to the GSM system is determined by the resonance frequencies of the resonance system comprising the band-varying capacitor C35, the resonance capacitor C31, and the resonator 32, and the resonance system comprising the band-variable type capacitor C36, the resonance capacitor C32, and the resonator 33. The pass-frequency of the band-pass filter section of the filter 45 system is determined by the resonance frequencies of the resonance system comprising the band-varying capacitor C37, the resonance capacitor C33, and the resonator 34, and the resonance system comprising the band-varying capacitor C38, the reso-

nance capacitor C34, and the resonator 35.

[0028] When a positive voltage as a control voltage is applied to the voltage controlling terminal CONT1, the PIN diodes D1 through D4 are on. Accordingly, the band-variable type capacitors C35 and C36 are grounded through the PIN diodes D1 and D2, both of the two attenuation pole frequencies are decreased. Similarly, the band-varying capacitors C37 and C38 are grounded through the PIN diodes D3 and D4, and the pass-frequencies are decreased. To the contrary, when a negative voltage is applied as a control voltage, the PIN diodes D1 through D4 is off. The PIN diodes D1 through D4 may be off by setting the control circuit which feeds a control voltage to the voltage controlling terminal CONT1, to have a high impedance of at least 100 K Ω , and also, preventing a voltage from being applied to the voltage control terminal CONT1. Accordingly, the band-varying capacitors C35 and C36 are in the open state, so that both of the two attenuation pole frequencies are increased. Similarly, the band-varying capacitors C37 and C38 are in the open state, so that the pass-frequencies are increased.

[0029] As described above, the frequency variable type filter 45 which corresponds to the GSM system can be given two different pass-bands (the difference between the frequencies is dozens MHz, which is relatively low), by controlling the voltage to ground the band-varying capacitors C35 through C38 or to open the capacitors.

[0030] The transmission frequencies allotted to the GSM system are 890 - 915 MHz (center frequency = 902.5 MHz), and the receiving frequencies are 935 - 960 MHz (center frequency = 947.5 MHz), as shown in FIG. 3. The separation between the transmission frequency and the receiving frequency is 45 (=947.5 - 902.5) MHz. When a GSM signal is fed, a positive voltage is applied to the voltage control terminal CONT1 of the frequency-variable type filter 45 so that the PIN diodes D1 through D4 is on, the band-varying capacitors C35 through C38 are grounded, and thereby, the pass-band is reduced. When a GSM signal is received, a negative voltage is applied to the voltage control terminal CONT1 so that the PIN diodes D1 through D4 are off, and the band-varying capacitors C35 through C38 are opened to enhance the pass-band.

[0031] The trap frequency of the band-elimination filter section of the frequency-variable type filter 46 which corresponds to the DCS system is determined by the resonance frequencies of the resonance system comprising the band-varying capacitor C48, the resonance capacitor C44, and the resonator 36, and the resonance system comprising the band-varying capacitor C49, the resonance capacitor C45, and the resonator 37. The pass-frequency of the band-pass filter section of the filter 46 is determined by the resonance frequencies of the resonance system comprising the band-varying capacitor C50, the resonance capacitor C46, and the resonator 38, and the resonance system comprising the

band-varying capacitor C51, the resonance capacitor C47, and the resonator 39.

[0032] When a positive voltage as a control voltage is applied to the voltage controlling terminal CONT2, the PIN diodes D5 through D8 are on. Accordingly, the band-varying capacitors C48 and C49 are grounded through the PIN diodes D5 and D6, respectively, both of the two attenuation pole frequencies are decreased. Similarly, the band-varying capacitors C50 and C51 are grounded through the PIN diodes D7 and D8, and the pass-frequency is decreased. On the other hand, when a negative voltage is applied as a control voltage, the PIN diodes D5 through D8 is off. The PIN diodes D5 through D8 may be off by setting the control circuit, which feeds a control voltage to the voltage controlling terminal CONT2, to have a high impedance of at least 100 K Ω to prevent a voltage from being applied to the voltage control terminal CONT2. The band-varying capacitors C48 and C49 are in the open state, and both of the two attenuation pole frequencies are increased. Similarly, the band-varying capacitors C50 and C51 are in the open state, so that the pass-frequency is increased.

[0033] As described above, the frequency variable type filter 46 which corresponds to the DCS system can be given two different pass-bands (the difference between the frequencies is dozens MHz, which is relatively low) by grounding the band-varying capacitors C48 through C51 or to open the capacitors by voltage-controlling.

[0034] The transmission frequencies allotted to the DCS system are 1710 - 1785 MHz (center frequency = 1747.5 MHz), and the receiving frequencies are 1805 - 1880 MHz (center frequency = 1842.5 MHz), as shown in FIG. 3. The separation between the transmission frequency and the receiving frequency is 95 (=1842.5 - 1747.5) MHz. The numerical value, if it is frequency-corrected with reference to 900 MHz, becomes a half of the value, that is, about 43 MHz. This separation is substantially equal to that of the GSM system. When a DCS signal is fed, a positive voltage is applied to the voltage control terminal CONT2 of the frequency-variable type filter 46 so that the PIN diodes D5 through D8 is on, the band-varying capacitors C48 through C51 are grounded, resulting in the reduction of the pass-band. When a DCS signal is received, a negative voltage is applied to the voltage control terminal CONT2, so that the PIN diodes D5 through D8 are off, and the band-varying capacitors C48 through C51 are opened to enhance the pass-band.

[0035] Thus, the small-size duplexer 31 which can correspond to the two different portable telephone systems (GSM and DCS systems) having frequency bands different significantly can be obtained. Further, by selling the PIN diodes D1 through D8 to be on when GSM and DCS transmitting signals are passed through the frequency-variable type filters 45 and 46, the PIN diodes D1 through D8 are stable even if a high power

high frequency signal is input through the external terminals P1 and P2, since a positive voltage is applied to the anodes of the PIN diodes D1 through D8, and thereby, the fluctuation of the frequency characteristics can be inhibited. Further, by setting the PIN diodes D1 through D8 to be off when GSM and DCS receiving signals are passed through frequency-variable type filters 45 and 46, it is unnecessary to apply a voltage to the voltage control terminals CONT1 and 2 while the receiving signals are waited for. Therefore, the power consumption can be decreased.

[Second Embodiment, FIG. 4]

[0036] FIG. 4 shows an electric circuit of a duplexer according to a second embodiment of the present invention. A duplexer 61 is the same as the duplexer 31 of the first embodiment except that variable capacity diodes D61 through D68 are used as the voltage-controllable reactance element, and a switch 69 is used instead of the transmission lines 40 and 41. The variable capacitance diodes D61 through D68, with the respective anodes grounded, are electrically connected to the resonators 32 through 39 through the band-varying type capacitance C35 through C38 and C48 through C51. As the switch 69 of the synthetic circuit 47, a GaAs switch, a diode switch, or the like are employed. The duplexer 61 can be switched to either of the GSM and DCS systems by means of the switch 69.

[0037] The duplexer 61 having the above configuration has the same action and effect as the duplexer 31 of the first embodiment. Resistors may be used instead of the choke coils L2 through L9, so that the circuits on the voltage control terminals CONT1 and 2 side are resistors having a high impedance. In this case, the control voltage feeding resistors R1 and R2 can be omitted.

[Third Embodiment, FIG. 5]

[0038] The third embodiment is an embodiment of a communication apparatus of the present invention. A portable telephone will be described as an example.

[0039] FIG. 5 is an electric circuit block diagram of the RF section of a portable telephone 120. In FIG. 5, reference numerals 122 and 123 designate an antenna element and a duplexer, respectively. The numerals 131a through 139a designate devices corresponding to the GSM system, while the numerals 131b through 139b designate devices corresponding to the DCS system. Transmission-side isolators are designated by the reference numerals 131a and 131b, transmission-side amplifiers by 132a and 132b, transmission-side inter-stage band-pass filters by 133a and 133b, transmission-side mixers by 134a and 134b, receiving-side amplifiers by 135a and 135b, receiving-side inter-stage band-pass filters by 136a and 136b, receiving-side mixers by 137a and 137b, voltage-controlled oscillators (VCO) by 138a and 138b, and local band-pass filters by 139a and 139b.

[0040] In this case, as the duplexer 123, the duplexers 31 and 61 of the first and second embodiments may be employed. By mounting these duplexers 31 and 61, a miniaturized, light-weight portable telephone terminal device adaptable to the dual band system can be realized.

[Other Embodiment]

[0041] The duplexer and the communication apparatus of the present invention are not limited to the above-described embodiments. Modification and variation of the invention is possible without departing from the spirit and scope thereof. Particularly, as the synthetic circuit 47, a phase circuit having an arrangement in a T-shape formed by use of coils L80 and L81 as lumped constant elements and a capacitor C80 may be employed as shown in FIG. 6. The coil L80 is electrically connected between the frequency-variable type filter 46 and the antenna terminal ANT. The capacitor C80 is electrically connected between the ground and the antenna terminal ANT.

Claims

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1. A duplexer (31; 61), comprising:

a first frequency variable type filter (45) including a voltage-controllable reactance element and operative to switch transmitting - receiving frequencies corresponding to a first communication system (GSM);

a second frequency variable type filter (46) including a voltage-controllable reactance element and operative to switch transmitting - receiving frequencies corresponding to a second communication system (DCS);

a synthetic circuit (47) electrically connected between one end of said first frequency variable type filter (45) and one end of said second frequency variable type filter (46);

an antenna terminal (ANT) electrically connected to said synthetic circuit (47);

a first external terminal (P1) electrically connected to the other end of said first frequency variable type filter (45); and

a second external terminal (P2) electrically connected to the other end of said second frequency variable type filter (46).

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2. A duplexer (31) according to Claim 1, wherein the reactance element is a PIN diode (D1, D2, D3, D4, D5, D6, D7, D8).

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3. A duplexer (61) according to Claim 1, wherein the reactance element is a variable capacitance diode (D61, D62, D63, D64, D65, D66, D67, D68).

4. A duplexer (31) according to Claim 2, wherein the PIN diode (D1, D2, D3, D4, D5, D6, D7, D8) is in the ON state when a transmitting signal is passed through the frequency variable type filter (45, 46), and the PIN diode (D1, D2, D3, D4, D5, D6, D7, D8) is in the OFF state when a receiving signal is passed through the frequency variable type filter (45, 46).
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5. A duplexer (31; 61) according to any one of Claims 1 through 4, wherein a resonator (32, 33, 34, 35, 36, 37, 38, 39) constituting said frequency variable type filter (45, 46) is a dielectric resonator.
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6. Communication apparatus (120) including the duplexer (31; 61) according to any one of Claims 1 through 5.
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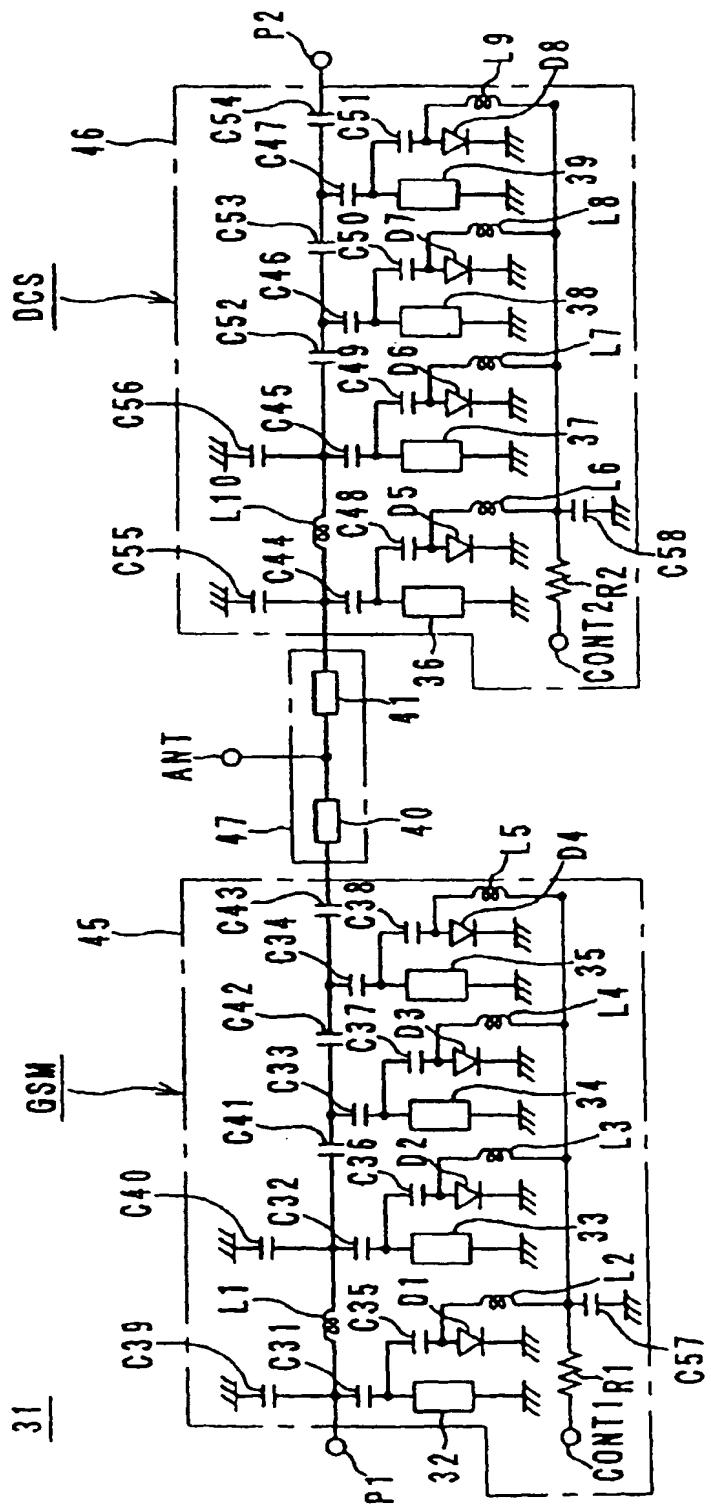


FIG. 1

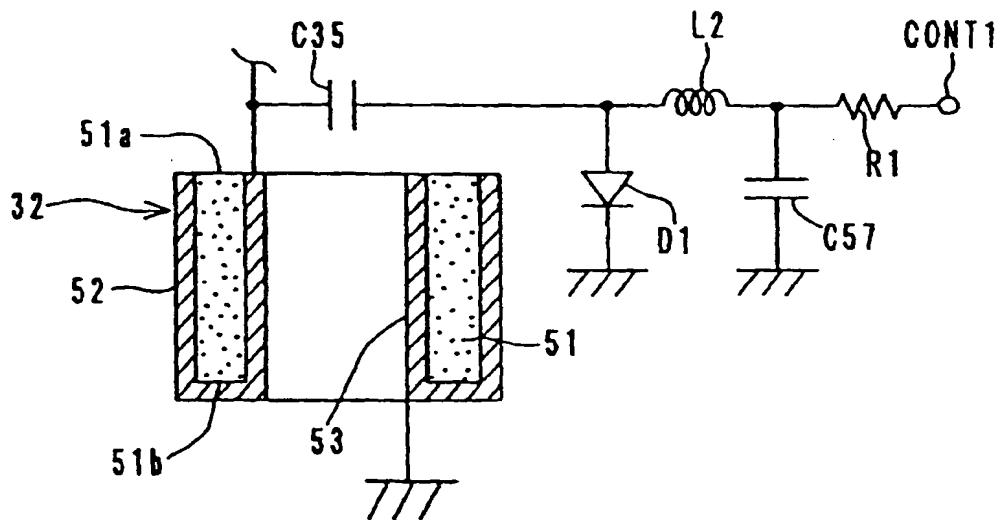


FIG. 2

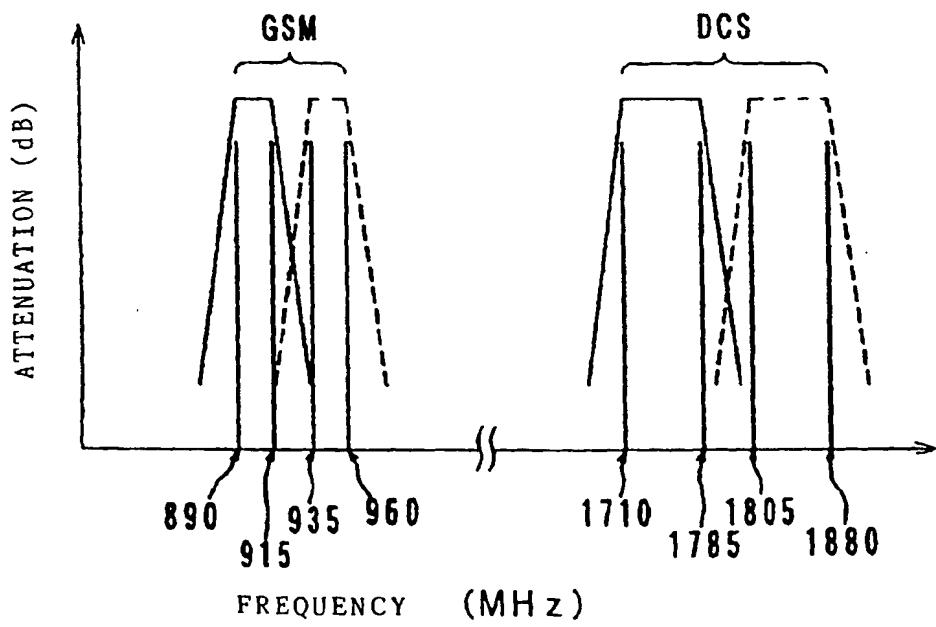


FIG. 3

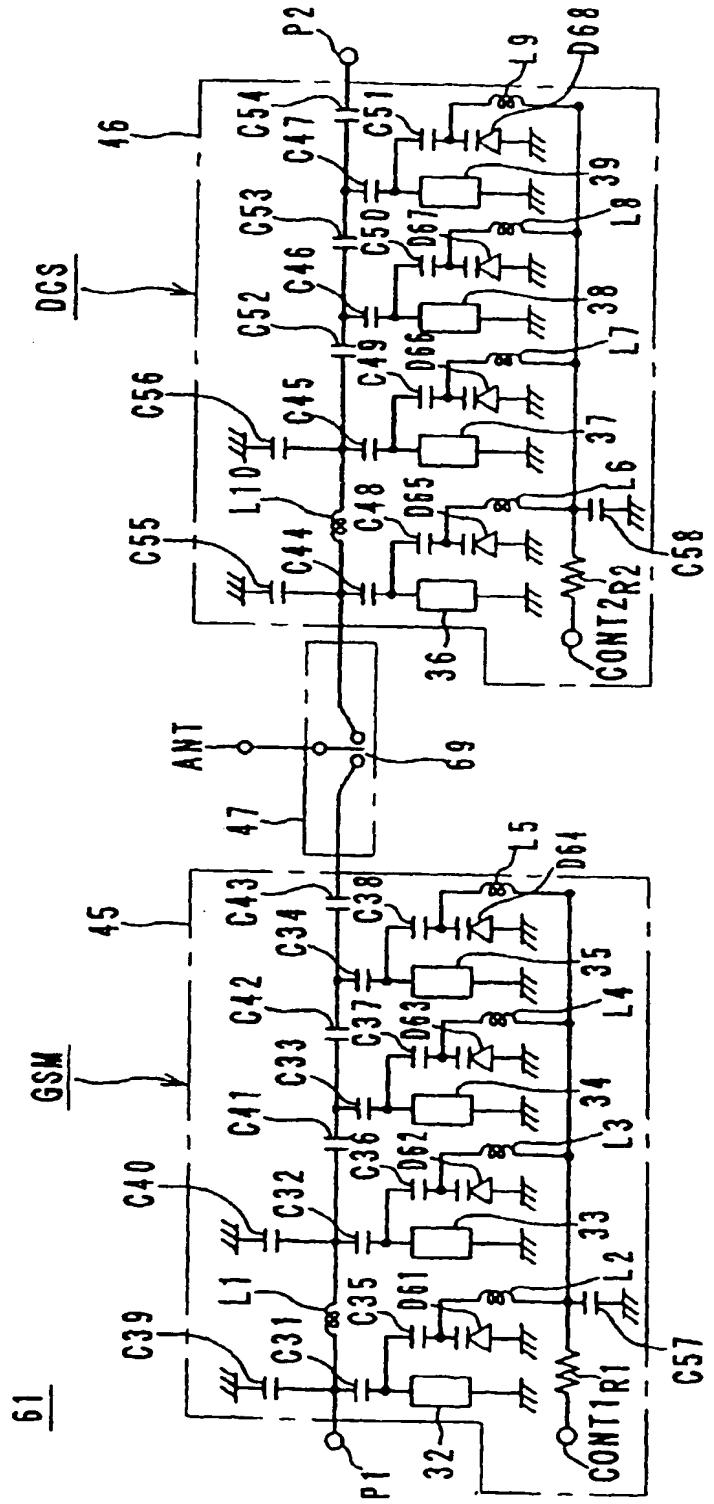


FIG. 4

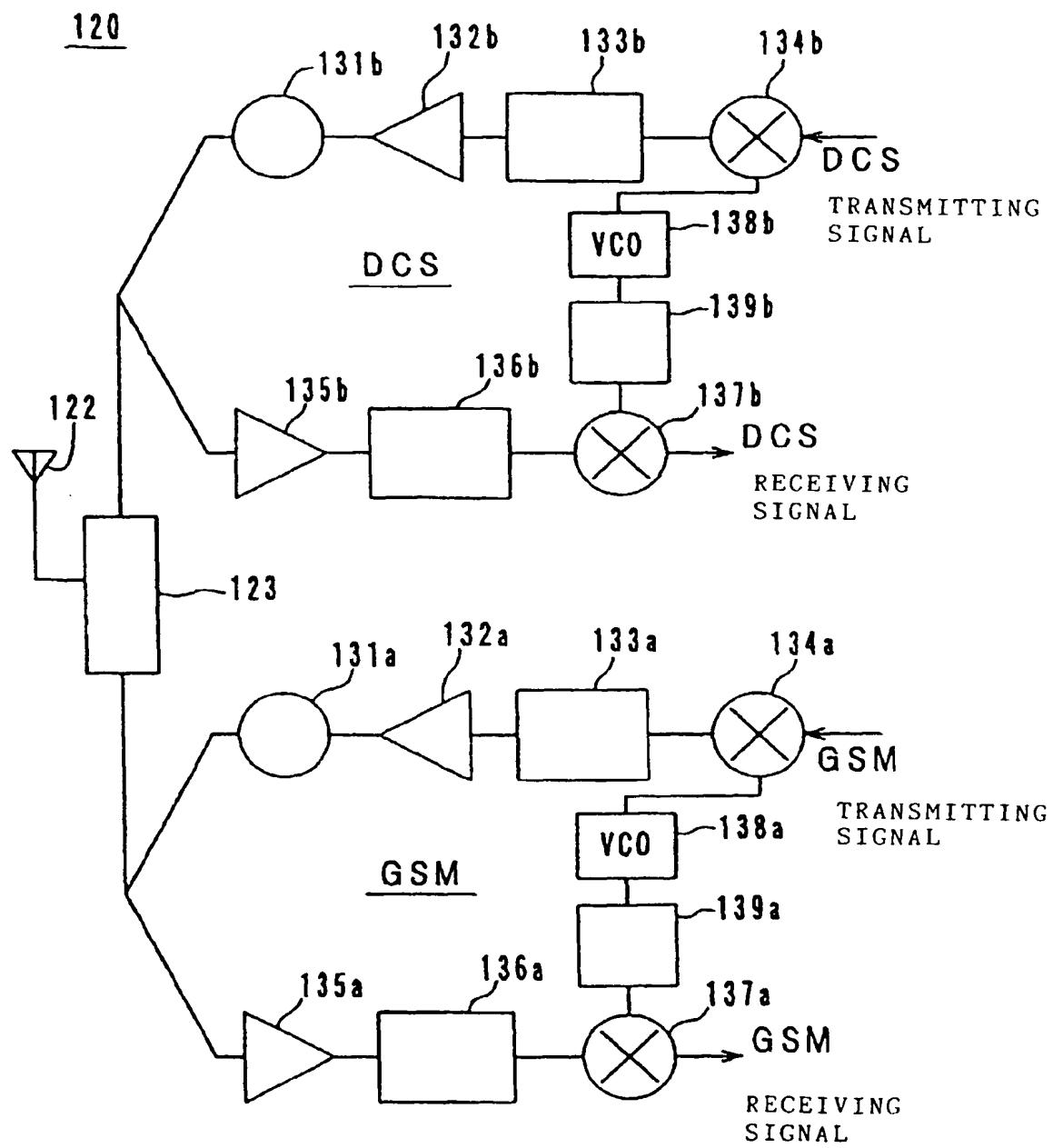


FIG. 5

